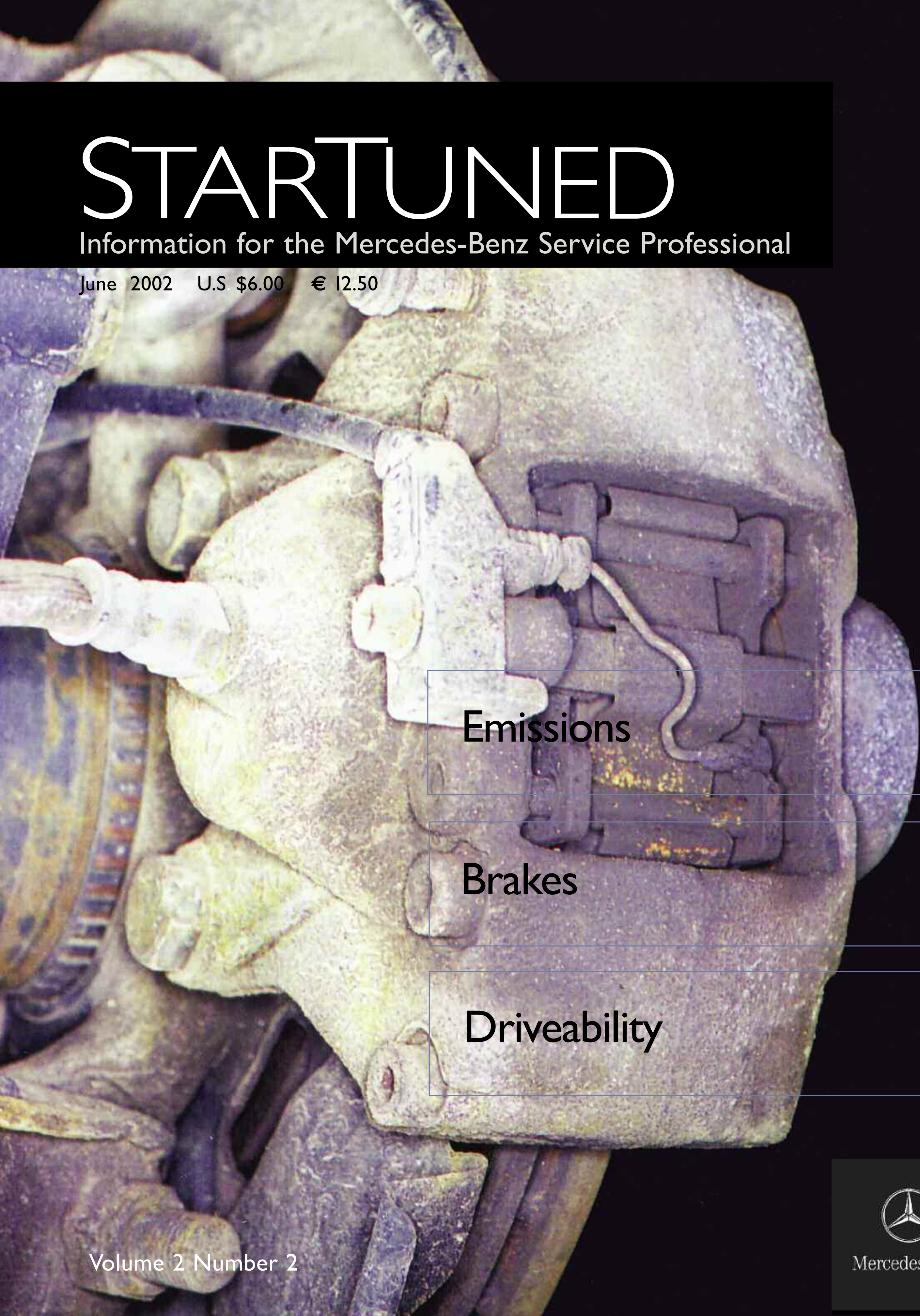
StarTuned

Information for the Mercedes-Benz Service Professional

June 2002 U.S $6.00 € 12.50



Emissions

Brakes

Driveability

Volume 2 Number 2

Mercedes-Benz

To Our Readers

Welcome to *StarTuned*, the new magazine for independent service technicians working on Mercedes-Benz vehicles. Mercedes-Benz both sponsors *StarTuned* and provides the information coming your way in each issue.

The worldwide carmaker wants to present what you need to know to diagnose and repair Mercedes-Benz cars accurately, quickly, the first time. Text, graphic, on-line and other internal information sources combine to make this possible.

Feature articles, derived from official company information sources, focus on being useful and interesting. Our digest of service bulletins will help you solve unanticipated problems quickly and expertly. With our list of Mercedes-Benz dealers you can find original, Mercedes-Benz factory parts nearby.

We want *StarTuned* to be both useful and interesting, so please let us know just what kinds of features and other information services you'd like to see in it. We'll continue to bring you selected service bulletins from the Mercedes-Benz company and articles covering different systems on these vehicles.

Send your suggestions, questions or comments to us at:

StarTuned
One Mercedes Drive
Montvale NJ 07645
or e-mail us at:
novaks@mbusa.com
or phone us at:
800-225-6262 ext. 4347

STARTUNED

Information for the Independent Mercedes-Benz Service Professional

June 2002 U.S. $6.00 € 12.50

FEATURE ARTICLES

DEPARTMENTS

StarTuned is a quarterly publication of Mercedes-Benz. No part of this newsletter may be reproduced without the express written permission of Mercedes-Benz. **Editorial and Circulation Offices:** 598 Pine Point Drive Akron, Ohio 44333 **Caution:** Vehicle servicing performed by untrained persons could result in serious injury to those persons or others. Information contained in this newsletter is intended for use by trained, professional auto repair technicians **ONLY.** This information is provided to inform these technicians of conditions which may occur in some vehicles or to provide information which could assist them in proper servicing of these vehicles. Properly trained technicians have the equipment, tools, safety instructions, and know-how to perform repairs correctly and safely. If a condition is described, **DO NOT** assume that a topic covered in these pages automatically applies to your vehicle or that your vehicle has that condition.

Emissions Mission: Detox

The oxygen sensor is the heart of the mixture control system. Because of the unique properties of its zirconium ceramic and platinum catalytic surfaces, it reflects the amount of residual oxygen in the exhaust with great precision, allowing a similar precision in the mixture calculations.

We want reliable, fuel-efficient cars, yet we also want breathable air. So we control vehicle exhaust because all the undesired emissions are either unburned (that is, wasted) fuel or the more or less unpleasant byproducts of combustion. In this issue of *StarTuned*, we'll take an overview of the emissions controls on Mercedes-Benz cars, and in later issues we'll pinpoint different emissions subsystems and how they've changed over time. As usual with things automotive, you have to know how they work when they do work before you can diagnose or repair them when they don't.

While there are various ways to sort emissions controls, this is the set we'll use here: mixture controls, combustion controls, exhaust controls and fuel vapor controls. You may argue that a PCV or an EGR really affects exhaust rather than mixture, but as long as we have clear what each subsystem does, where we list it here won't make any work difference on the shop floor.

Mixture Controls

The major role of emissions control systems is keeping the fuel-air mixture in the *stoichiometric* or 'Goldilocks' proportion, not so rich there is still fuel in the exhaust, not so lean the cylinder misfires, but just right to allow the catalytic converter to clean the exhaust as much as possible. What's more, we'd like to derive some transportation use from the combustion, too.

A mixture too rich wastes fuel and spills it into the exhaust (to say nothing of washing down the cylinder walls, diluting the crankcase oil and thus accelerating mechanical wear). Too lean also wastes gas, spilling it into the exhaust (because the misfiring cylinder's gas just blows through the pipe and the other cylinders that don't misfire have to take up the torque slack by burning still more fuel). Not much of a choice between these options!

That was why carmakers abandoned carburetors and opted for a fuel injector in each cylinder's intake port. Fuel mixture concentrations often vary by as much as 60 % on carbureted engines, even with the elaborate measures eventually taken to try to equalize delivery to the cylinders. That meant some cylinders ran too lean while others ran too rich – in the same engine at the same time! If you think fuel injection systems are complex, just look at the carburetors on any model vehicle in the last year before they were replaced with injectors. Do you fancy, say, tracing a vacuum-related problem on one of them? How about an intermittent partial-throttle surge?

In one stroke, port fuel injection reduces that variation and complexity tenfold. You'd have to have individual carburetors for each cylinder, all of them perfectly synchronized, all perfectly adjusted, all of them with zero linkage slack or play – all to approach the mixture precision the ported injectors have automatically, right out of the box. And individual carburetors are much more complex and trouble-prone than individual fuel injectors. So engines with individual carburetors for each cylinder didn't happen on cars. Clearly, in the real world they couldn't have.

There are two varieties of port fuel injectors, pulsed or continuous. Pulsed injectors usually share a largish pipe from which a row of them draw their gasoline, the fuel manifold or fuel rail. Its size comes from the need to have enough pressurized fuel in a single reservoir (or pair of reservoirs on a V-form engine) that no single injector's pulse will drop the reservoir pressure enough to affect delivery to the upcoming cylinders. Pulsed injectors are also electromagnetic valves, so each one has an electrical connector. Power is constant; ground is pulsed.

Continuous injectors use long, separate tubes, steel lines like Diesel injection lines or even braided steel lines, one for each injector. Each injector's fuel line extends from the fuel distributor to the individual fuel injector, and they are ordinarily of equal length so the resistance to flow is identical for each cylinder. These lines do not need to be nearly so

Later model vehicles use multiple oxygen sensors, with those downstream monitoring the effectiveness of the catalytic converter. If the converter works properly, reducing and oxidizing the undesired elements in the exhaust, the downstream oxygen sensor should exhibit little or no pattern. When it starts to echo the signal from the upstream sensor, the catalytic converter is out of business.

thick as a fuel rail because fuel moves smoothly through them to only one cylinder and at a relatively constant speed without pulses. The flow volume varies with engine load and speed, but nothing that happens on one injector's hydraulic circuit necessarily affects another's.

Mercedes-Benz has used both types of injector. While the company's automotive history includes such exotics as the Diesel-like direct, into-the-chamber injection system of the Gullwing SL, the earliest recent fuel injection systems were versions of the Bosch D-Jet, spraying fuel with each cylinder cycle and using air pressure in the intake manifold as the primary input to calculate injector on-time. And the on-time duration corresponds directly to the amount of fuel injected, just as on later pulsed injection systems.

The continuous injectors are what you see most often, components of the various K-Jet systems on the cars. Fuel sprays from the K-Jet injectors as long as the engine is running, but its volume changes to correspond with the amount of air entering the engine at the same time. The correspondence derives, at least in the first systems, entirely mechanically through the fuel distributor, essentially a complex hydraulic valve activated by a lever at the extreme end of which is a round plate in a funnel, pushed by the incoming air.

The early, plain-vanilla K-Jet systems were much better than carburetors in emissions terms, but most cars built in the last twenty years now employ feedback systems based on an oxygen sensor in the exhaust. After all, it's very well to be able to control fuel mixture with great precision, but you need some constant source of fresh information about the effect your mixture changes have on the combustion.

The oxygen sensor once warmed up and at work, functions almost like a battery, generating a very low amperage, very low voltage signal inversely corresponding to the amount of oxygen left in the exhaust stream. The more residual oxygen there is in the exhaust, the lower is the sensor's output voltage; the less residual oxygen there is, the higher.

We don't have space this month to go into exactly how the oxygen sensor manages this feat. Briefly, it is 'transparent' to oxygen ions – O_2 molecules separated into positively charged individual oxygen atoms – but not to anything else. As the oxygen atoms, properly described as ions because after O_2 separates into two atoms of oxygen each carries a small positive charge, as they travel through the sensor's ceramic thimble, they carry electrons with them, forming a small voltage and current. The signal that electron transfer generates is enough for a computer to trace and to use for final adjustments to the fuel mixture either richer or leaner, as the state of the residual oxygen in the exhaust indicates. When working properly, the system should include an oxygen sensor cycling regularly between about 0.3 volts and about 0.9 volts.

As the signal cycles, the mixture the computer commands also cycles, and the resulting combustion mixture oscillates back and forth across the 'stoichiometric notch' the range of mixture producing the least exhaust emissions once the catalytic converter finishes oxidizing and reducing the gasses. It comes close to the mixture that would yield the highest fuel economy, too, but we and every other society that has concerned itself with the question have chosen to favor breathable air over the last iota of fuel economy.

Later model cars use oxygen sensors with internal electric resistance heaters to get them functional more quickly (they have to reach about 600 degrees F to allow oxygen ions through and get to work producing a signal) and to keep them working under low-temperature, low-engine-load conditions, like extended cold-weather idle. Even newer cars use sets of multiple oxygen sensors, to monitor the mixture of different banks of V-form engines more accurately and to monitor the effectiveness of catalytic converters. While the later computer uses these signals in more complex ways (not only to monitor the function of the converter but for even more precise fuel mixture control), the sensors themselves are not different from the original ones. The oxygen sensor, or the set of multiple oxygen sensors on cars so equipped, are the fuel injection system's last look at the product of its previous work and the basis for the last calculations of the amount to inject next.

Oxygen Sensor

On the KE-Jet systems, those using continuous injectors in conjunction with oxygen-sensor feedback and computer controls, the final device for adjusting the fuel-air mixture is the electrohydraulic actuator or EHA. It is electric in that it is a variable-strength electromagnet, changing the force on a valve that leaks fuel from one side of the fuel distributor metal diaphragm to the return circuit – or that does not, depending on the command from the computer. This command takes the form of current, of amperage. An electromagnet responds to current only, not to voltage, so that is what you measure to check the system (it should fluctuate in response to the oxygen sensor).

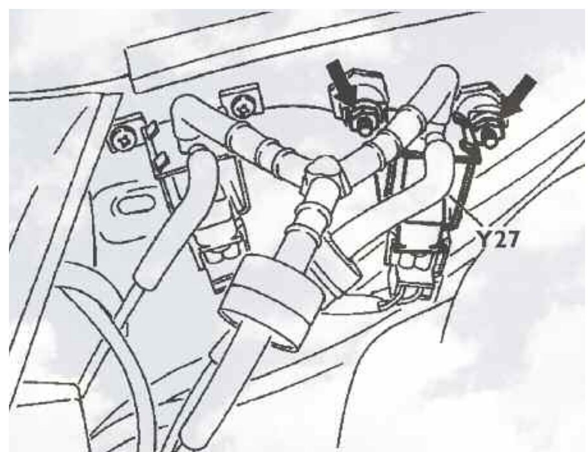
Keep in mind while the EHA does not respond to voltage, it does respond to polarity, so you need either an ammeter that reflects that electrical property or a voltmeter to supplement your ammeter. Many cars will use the EHA to shut off all fuel delivery during closed-throttle deceleration under normal driving circumstances.

There are no specifications to match current oxygen sensor output with EHA current because there are many other factors involved, including the history of where the signal and the command were a moment ago. But if you find a cycling correspondence between them, a correspondence in the range you'd normally expect to find from previous, known-good cars you've observed, the system is adjusting the mixture correctly in response to the feedback signal. If not, it's time to start digging.

Where to dig when working on a particular system we'll cover in detail in later articles. In general, you want to confirm that whatever signal the oxygen sensor generates gets to the computer untampered with by interference from high resistance, shorts or spurious electromagnetic induction and the like. The same applies to the command from the computer to the EHA; it should arrive at the actuator with the same electrical properties it left the computer. In either case, if things are otherwise, check the connecting harness. This is the usual computer-diagnostic procedure of determining whether the information coming in is good and whether the information going out is at least plausible. While it is unlikely that a control unit is defective, if you find one with good information getting to it but bad or no commands coming out, you may have found one that has failed.

The later Mercedes-Benz cars use individually pulsed fuel injectors rather than continuous. The reason for this is twofold: First, there is an optimal moment to spray the fuel so all of it vaporizes and flows immediately into the combustion chamber rather than condensing on the intake manifold walls or the back of the intake valve. Second, there was still some variation in the flow from one continuous injector to the next because whatever the level of the manufacturing care, there are tolerance variations affecting fuel delivery pattern and volume. There are with the individually pulsed injectors, too, of course, but you can slightly vary the pulse command one injector at a time to correct for that.

The K-Jet and KE-Jet systems measure intake air by the deflection of the lever at the air horn. Later systems like Motronic measure air with a hot-wire system. This more precise measurement calculates the mass of the intake airflow by the amount of heat carried off from a special platinum wire in the airstream. More air carries off more heat and vice-versa. At the heart of the sensor is an electrical circuit called a Wheatstone bridge, an array of fixed and variable resistors that detects small changes in resistance very accurately. The two variable resistors in the sensor reflect the temperature of the incoming air and its volume. There is not a return signal to the computer directly; instead the computer internally monitors the current required to keep a voltage in the sensor constant.



The EGR switchover valve controls direct actuation of the EGR valve itself. The conditions under which the system uses EGR vary from model to model and from year to year. In fact, those conditions vary from place to place as well: In some model years there were differences for California-specific models from the federal. The only way to be sure to get the correct part is to get it from the only source of accurate information about which part goes on which model.

Hot-wire sensors include a 'burn-off' cycle. When the engine is first shut down, the computer will send a high current through the wire for about a minute to burn off any condensed fuel vapors, bits of paper filter element or whatever may have fallen on the wire. Obviously, anything that might block the flow of air over the wire is going to render it inaccurate as a measure of the airflow mass.

Measuring air *mass* is an inherently more accurate way to calculate the incoming air when preparing the mixture because a mass does not need correction factors for temperature, humidity, altitude or any of the other variables. Mass is a direct measure of the number of molecules in the intake, and the number of oxygen molecules is a constant fraction of that. Fine-tuning the mixture, naturally, falls to the signal coming from the later models' oxygen sensors.

Combustion Controls

While preparation of the intake mixture is the major technology affecting the vehicle's emissions, there are two measures more specifically affecting what happens in the combustion chamber itself: exhaust recirculation and variable valve timing.

The exhaust gas recirculation (EGR) system exists to prevent or reduce the formation of oxides of nitrogen in the combustion chamber, some of which chemical combinations degrade the air quality. Nitrogen constitutes about 80 % of the air and ordinarily (lucky for us!) does not combine with oxygen. But at temperatures in excess of 2500 degrees F, such combinations can occur. These temperatures can occur in combustion chambers when the mixture is relatively lean and the load is relatively high. Unfortunately, these are the very conditions we'd like to see during sustained high cruise, because they produce the best fuel economy.

EGR systems use metered amounts of exhaust mixed into the incoming mixture almost like the carbon rods in nuclear reactors – just there to slow the action. Any inert gas, like helium or argon, would work as well; but exhaust is already on hand, costing nothing. The effect is to slow combustion, but not affect it otherwise. Burning the same fuel over a longer period clearly yields lower peak temperatures, the very objective we were after. Adding recirculated exhaust to the intake also has the minor positive benefit that it reduces the intake manifold vacuum (or equivalently, that it increases the intake manifold pressure), thus reducing the pumping losses of the engine. So EGR can have a small but beneficial effect on fuel economy.

Over the years Mercedes-Benz has used a variety of different EGR systems, so we can't detail all of them here. Perhaps the most common problem you may find, particularly on vehicles that have been in use for a long time, is the gradual buildup of deposits in the EGR passages. This is a natural and unavoidable consequence of exhaust, which contains the deposits as leftovers from the combustion (EGR picks up the exhaust right out of the combustion chamber, not downstream after the converter).

Exhaust Controls

One constant on the exhaust system of every car for the last twenty years is the catalytic converter. Current cats are three-way oxidation/reduction versions that both oxidize any residual fuel in the exhaust and reduce, i.e., neutralize any of the NOx gas we discussed above in the section on EGR. These chemical functions usually occur alternately, that is, the converter oxidizes while the engine runs on the rich side of stoichiometry and then reduces when the mixture oscillates over to the lean side.

Each of the sensors in a fuel injection system serves to modify the calculation of how long the next fuel injection will last, and thus how much fuel will be injected. Sensors like the throttle position sensor or the mass airflow sensor put the system within the large-scale range of the correct mixture; information from the oxygen sensor provides the last modification of the injector on-time algorithm.

Over the last years, carmakers have installed additional oxygen sensors downstream of the catalytic converters. The principal function of these sensors is to monitor the catalytic converter. Their signal should wander vaguely over the sub-one-volt range rather than oscillate regularly like the otherwise identical oxygen sensors ahead of the cat. But they are also available to the computer as inputs for calculating the fuel mixture in upcoming combustion events.

But upstream of the catalyst, even upstream of any pre-cats the car may have, is the air injection system found on many vehicles (emissions equipment varies depending on the emissions regulations in effect in the place and at the time where and when the car was first sold). An air pump, when one is installed, pumps air directly into the exhaust manifold, right behind the exhaust valves where the exhaust is at its hottest. The major function of this is to clean the exhaust as much as possible when the engine first starts cold, before the oxygen sensor feedback system is at work, before the catalytic converter is warm enough to treat the exhaust. The air blown into the exhaust manifold at that point provides enough oxygen to burn the residual fuel necessary because a cold engine requires a rich mixture to fire dependably. This situation changes rapidly as the engine warms, but cold-startup emissions problems remain one of the combustion engineer's greatest challenges, and thus one of the automotive technician's, too.

Vapor Controls

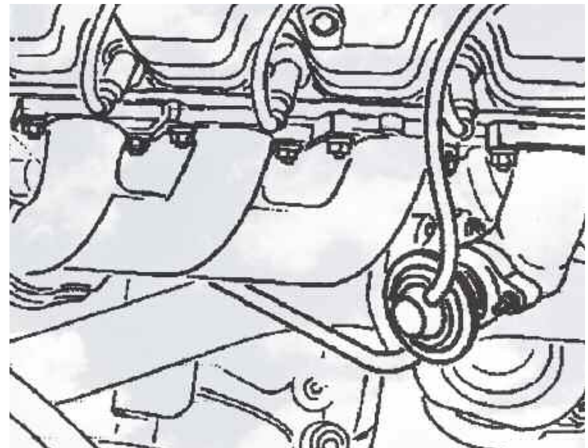
It's been said that on a new car with everything working properly, the major source of air pollution is the outgassing of certain hydrocarbons from the new tires and the evaporation of the last of the factory oil sprayed into the tire mold to release the finished tire after the rubber cools and cures. New rubber certainly has a characteristic smell that goes away as the tire ages. And rubber has many hydrocarbons in it.

But the kind of evaporated hydrocarbons we worry about don't come from road rubber, but from gasoline. This is a problem that can't go away with improved fuel blending or refining, because gasoline has to vaporize before it can burn in a combustion chamber. So there's a conflict between the need to get the fuel to evaporate as quickly as possible after it leaves the nozzle of the fuel injector and the need to prevent its evaporation when it's in the tank waiting for use. Fuel lines, the filler cap, the pump and filter and all the fuel injection apparatus under the hood are potential sources of evaporative emissions.

The major system to prevent a car from causing air pollution while it's sitting quietly and cool with the engine off is the charcoal canister system.

Pneumatic tubes from the vapor-filled top of the fuel tank lead to a canister filled with specially activated charcoal pellets. Fuel vapors *adsorb* – yes, that word's spelled right – onto the surfaces of the charcoal pellets. They do not dissolve or mix with the charcoal; they merely cling – adsorb – to the surfaces. Then once the engine is running the next time and has reached normal speeds and temperatures, the purge valve opens and flushes the charcoal canister out with fresh air, venting the stored fuel vapors into the intake manifold and combustion chambers where they are usefully burned.

The major service problems with the system come from two sources: leaks that develop in the pneumatic system, connecting tank to canister and canister to valve to manifold, and from car owner mistakes. The latter occur during refueling the vehicle. On older cars, before carmakers were onto the trick, some drivers would try to fill the tank to the point when they could see liquid fuel at the brim of the filler tube. That required nursing the fuel filler nozzle to squeeze in the last few cups of fuel. It also meant liquid fuel could sometimes move through the pneumatic lines to the canister.



The EGR valve itself need only collect exhaust from one runner since there is no reason to get a mixed sampling of the exhaust. As long as the cylinder used does not misfire, it produces an exhaust that will be effectively inert in the next combustion cycle, so the factory puts the valve in whatever place is easiest to reach without interfering with other components.

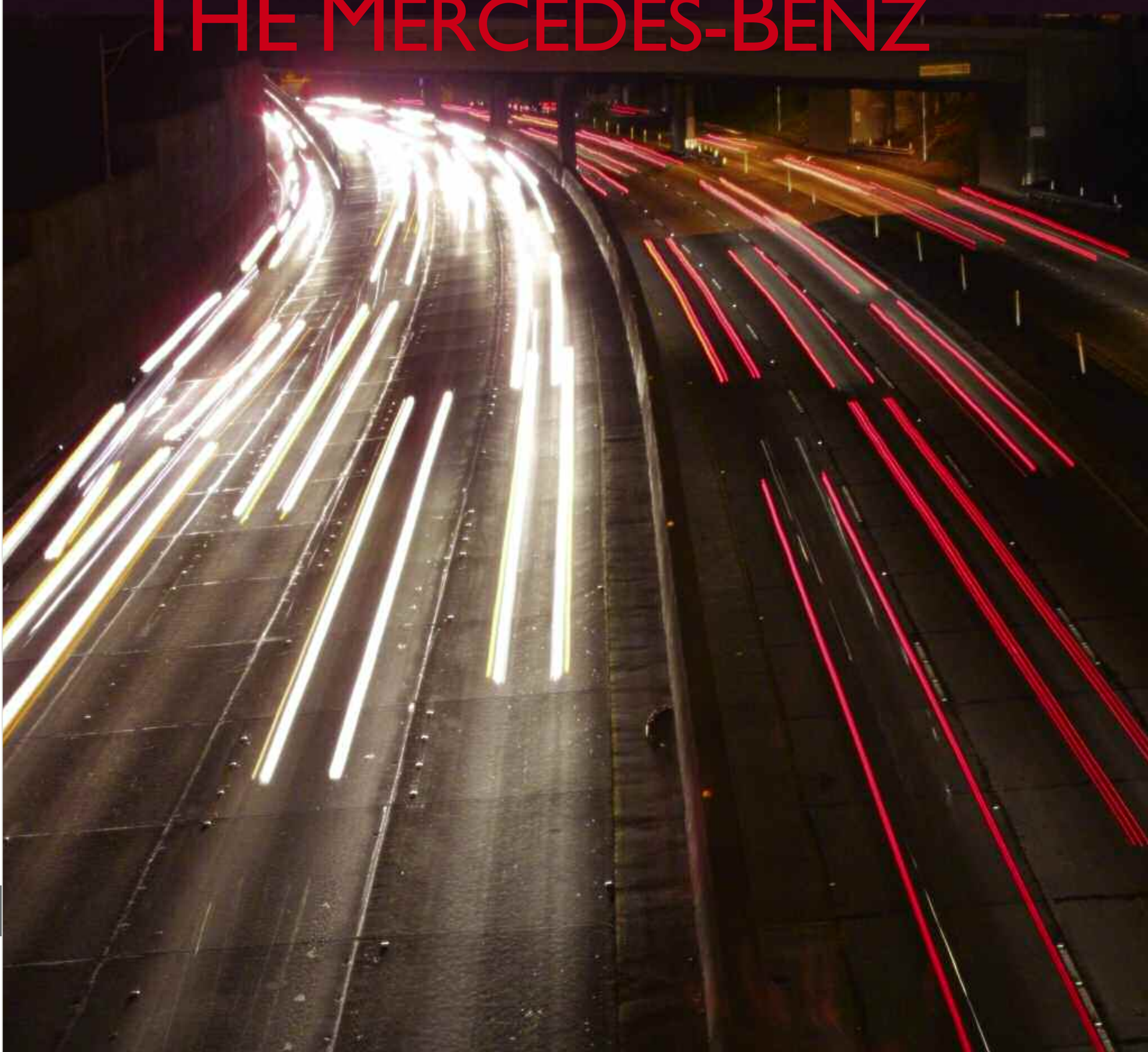
The canister can handle fuel vapors handsomely. But it can't handle liquid fuel at all because the pellets will partially dissolve and form a solid monolith, incapable of fuel vapor adsorption in the future. This overfueling also meant the car ran very rich when the purge valve opened and admitted not vapors but liquid fuel to the manifold.

You can't get that much fuel in the tank anymore, even if you dribble the last gas in with an eyedropper, because there are now vapor chambers in the tank that won't fill through the cap. But the next operator-error shops started to see came from very impatient drivers, people who left their engines running while they filled the tank.

Besides the risk of a fire, this also addles the OBD II system, which expects the engine to be off at the pump. To the vapor system self-diagnostics, opening the filler cap with the engine running looks like a very large-scale vapor leak, and it sets the corresponding code. If you find a car with such a code, keep in mind the problem may be driver-psychological, not vehicle-mechanical.

Them's The... Brakes!

Decelerating The Mercedes-Benz



There's a good chance, if you cut your tool-teeth working on domestic or Asian cars, the first thing that astonished you about a Mercedes-Benz was the sheer size of the brakes for the size of the car. The main reason they're so large is the *Autobahn*, the German superhighway system on which drivers choose their own cruise speed according to their vehicle's capacity and their own skills. Typically those vehicles and skills are very good, so average driving speeds on many stretches of the road are between 85 and 110 mph in dry weather. But many vehicles hold sustained cruise much higher than that.

Mercedes-Benz voluntarily limits their vehicles' top speed to 155 mph (250 kph), though many of their cars could drive considerably faster, absent the maximum speed governor. If you've ever driven a car at that ground-covering clip for any distance, you'll recall you were hardly clogging your lane at the time. It requires sustained attention to other traffic and the road in a way we don't experience here. It requires a road quality, a pavement engineering and construction economically incompatible with our multi-thousand-mile North American distances. But in a medium-sized country like Germany, that speed over a couple of hours means door-to-door car travel is about as fast as airline travel between most cities when you add to the flight time the ground connections at each end. The speed also presumes you have a well-engineered highway, first-quality tires and powerful brakes. Evidently they manage: The Autobahns are safer than our Interstates, factoring in all the variables.

The brake disk is the machine that converts vehicle movement to heat and gets rid of the heat to the air. Large brakes not only provide large friction surfaces for more deceleration-force, but also dissipate the heat better.

More to the point of brake systems, such high cruise speeds mean a much higher level of work for the deceleration machinery. Momentum goes up with the power of two, with the square of the speed. So stopping from 150 mph takes four times the distance and transfers four times as much heat as stopping the same car on the same surface under the same conditions from 75 mph – no sluggish pace, itself. If you've ever measured brake disk temperature after a 75-mph stop (Don't test one with your fingers! And don't ask me how I know that!), you can imagine what it is after a stop from a much higher speed. The decelerating Autobahn cruiser blows invisible plumes of brake-heated air through its wheels.

Momentum by the Power of Two

Have you ever driven in the mountains where there were runaway truck escape runs built at the end of steep stretches? These escape lanes provide some relatively safe way to stop a heavily laden, downhill truck if its brake pedal falls through the floor. There are two dynamic features of the escape lanes: First, they are ramrod-straight with no turns at all because a runaway truck isn't likely to turn very responsively. Second, the construction actively slows the truck, by soft sand, by a sequence of berms and by a steep uphill angle. I've only seen those lanes used a few times, and it's clear from the deep furrow in the sand and gravel, the excitement level was more than enough for that truck driver's day. While the experience surely beat running off the road anywhere else, it must certainly have been nothing like a gentle kiss from the tooth fairy.

The indications of dispersed kinetic energy were literally widespread. The halted truck blasted tons of sand for many yards in all directions, bashing through and propelling three of the huge, transverse sand berms. All the energy of the truck's runaway, gravity-sped descent down the mountain went into accelerating the sand and dirt forward, upward and outward. The soft surface let the truck sink to its frame, plowing with its wheels and bumper all the way. Whether the truck was repairable afterward, I don't know. It surely took many days' work with earthmoving equipment to put the runaway lane back into the emergency deceleration business. But the driver walked away, however shaken. That's because the runaway truck lane kept directional stability constant and provided sacrificial mass to absorb the energy.

Cars don't weigh nearly as much as tractor-trailers, but they have to disperse the heat of deceleration, too. People don't always realize the power-equivalent of their brakes, so let's look at it from the other end to get a more accurate picture. Suppose if you hold a 300-horsepower engine at wide-open-throttle for 30 seconds, you'll accelerate a 4000-pound car to 100 mph. I'm pulling these numbers out of my hat, of course, to keep the math simple, but they're reasonably close to the real world. Notice (except for a bit of air drag), it would take an equivalent of the same 300 horsepower to bring the same car to a stop in the same 30 seconds. In fact, however, brakes on every model car can vastly outperform the engine: Stand on the brakes and stand on the throttle, and you'll just overheat the engine and cook the transmission. But you won't move an inch.

The bulk of the deceleration in any car comes from the front brakes. This front caliper has the pad wear sensor on the outside of the disk and the wheelspeed sensor toward the hub. While road salt crusts the casting, good materials in the original part means there is little or no rust developing.

Actually, it would be a rare car that would, given good pavement and tires, take even ten seconds to stop from 100 mph. Mercedes-Benz braking systems, designed to provide sustained braking up to the traction limit even on Alpine Autobahns, have an even higher power equivalent. I don't have 100-to-zero performance figures for Mercedes-Benz cars, but feel entirely confident that any Benz built in the last 50 years can handily beat that ten-second figure. Newer ones could easily out-brake earlier. Chances are, Benz car brakes can put out well over 1500 horsepower-equivalent as long as the pavement and the tires cooperate. This is probably true of many manufacturers' current vehicles as well.

It isn't merely that the brakes convert the vehicle's movement into heat by forcing the friction surfaces of the brakes together. You have to get rid of that heat, too. The braking system must air-cool the brakes so they can keep absorbing more, newly developed heat. Without such heat transfer, the brakes would just heat up until either the components got so hot the pedal fades to the floor or the parts just melted.

Later model vehicles have more complex master cylinders to deal with the more complex brake systems. The extra bleed screw allows removal of all the air in the master cylinder itself should it require replacement or repair. The electronics control the pressure differential between the two hydraulic circuits.

The fundamental job of the brake system is to convert the structured kinetic energy, the momentum, of the moving car to the scattered, chaotic kinetic energy, the heat, of the surrounding air, just as the runaway lane converts the truck's downhill roll into flying sand and gravel. The brake system also holds the vehicle stopped at a standstill sometimes, but that does not involve the conversion of one type of energy into another. If hybrid vehicles ever become commonplace, they will perhaps succeed in recovering much of this energy through regenerative braking – drawing from the inertia of deceleration.

Braking consists of forcing friction surfaces, pads and disks together with a pressure corresponding to a multiple of the force the driver puts on the brake pedal. Since every car's braking capacity far exceeds its traction even under ideal circumstances, many current vehicles and all Mercedes-Benz include antilock brakes. The phrase *antilock brakes* is somewhat misleading: this is not really a system to optimize braking but a system to retain steering under any circumstances that might arise. The thinking is quite simple: If you were to lose controls of the vehi-

Tire Traction

Antilock braking is a steering-preservation system. No matter what the driver may do with the brake pedal (if the system works as designed), there will always be enough traction to steer the vehicle. Here's how the system works:

Every wheel's tirepatch has a certain amount of traction whenever it's touching the pavement. That amount of traction may be large or small depending on the type of tire and pavement, the weight on the wheel, the weather conditions and so on. We can visualize this traction as a line extending from the center of the treadpatch; the longer the line, the greater the traction. You can change the traction by changing the conditions – driving onto a wet surface or changing the weight on the wheel by turning or stopping.

But if the load you put on the treadpatch by any combination of steering and braking exceeds the traction, the tire will slip. If the brakes are applied, the wheel will rapidly start to lock up.

We think of tires as either having traction or not, and we suppose this distinction must reflect the difference between the treadpatch stationary with respect to the pavement or sliding. But the traction story is not that simple.

The wheel can affect the direction and speed of the vehicle up to the limit of its traction. Go beyond that, let the treadpatch slide along the ground to any significant degree, and you lose almost all traction. Most tiremakers build their tires so the extremes of traction announce themselves in the undoubted forms of louder noise and more alarming slipping, gradually but quickly evident to the driver. Then he or she knows that turning the wheel sharper or standing on the brakes harder will just disconnect the car from the road. They can do this because the rubber compound from which the business surface of the tire is compounded is relatively soft and flexible (there are really three 'business surfaces' when you count the areas where the beads grip the wheel rim). The tread rubber can flex and twist, so in a turn it typically starts to slip toward the rear edge of the moving treadpatch. When the surface slipping becomes large enough, the treadpatch and the pavement part company along their whole length.

All-out racing tires, however, often sacrifice that warning feedback range to get a few more foot-pounds of traction at the limit. Racers will gamble their skills against the risk to get just a bit closer to the edge of traction than their competitors. When hard-rubber racing tires do let go, of course, the car has all the traction and directional stability of a hard-rubber hockey puck.

Antilock brakes serve to preserve each wheel's traction up to the point when the laws of physics preclude any more. ABS works by reducing braking force when that force would be enough to push the traction over the perimeter described by the tip of that imaginary arrow we spoke of earlier. ASR and other traction control systems do the same thing by reducing delivered engine torque when that force

cle one at a time, the last one you'd want to lose is steering – up to that point, you could always aim for something soft or cheap.

There has been a progression of antilock systems on Mercedes-Benz vehicles, integrated into other traction-control systems like ASD, ASR, 4MATIC and so on, systems we'll treat in upcoming articles, systems you can get extensive information about from Mercedes-Benz Technical Information. The earliest, ABS alone, used three wheelspeed sensors, one on each front wheel and the third in the differential. The control unit and its connected hydraulics pulse the front wheels individually but the back brakes together. The reasoning is that in any situation requiring ABS activation, the rear brakes contribute minimally to the deceleration but very significantly to the directional control (lose rear traction and you spin), so the system can pulse them together to correspond to the wheel with less traction. This also insures retention of rear traction, or else there is no steering even with good traction at the front because the vehicle loses directional control.

Wheelspeed sensors are electromagnetic pulse generators and seldom go bad unless there is physical damage either to the sensor, to its connecting harness or to the toothed ring machined into the hub, generating the signal pulses in the sensor's coils. Conduct a thorough visual inspection and check the sensor for continuity and for resistance within specs. Be sure to rotate the wheel through a complete turn so you can look closely at all the spaces between the teeth. Road grit and debris often includes metallic particles, and should one lodge between the sensor teeth, that can disrupt the magnetic field. The sensor expects equidistant teeth, so a gap filled with the metal particle just looks like one long tooth to the control unit. That signal looks just like what you'd get with a wheel in the first stage of lockup, so the system may pulse the brake pressure, or on later self-diagnostic versions it may flag the wheelspeed sensor circuit as flawed.

The control units for ABS are among the most reliable, seldom requiring replacement except after physical damage, in an accident for instance. As you know, should the ABS system toggle itself off for a sensor or actuator fault, or should it merely fail for some other reason, the car still has full power braking that can stop the car with full force. What's lost with ABS off is the capacity to selectively pulse individual brakes to retain steering and directional control simultaneously during full braking force.

When flushing brake fluid, first draw all the fluid out of the reservoir itself and replace it with new. Some shops prefer using a pressure bleeder; some prefer either gravity or vacuum bleeding procedures. In any case, follow the bleed sequence for the vehicle you have on your rack.

One of the service problems entailed by ABS, however, is the increased complexity of the work when bleeding the brakes to flush the brake system of old brake fluid during regular replacements, or when bleeding the air out after some work that required opening a hydraulic circuit. If the procedure does not proceed in the correct sequence, there can be old fluid left in part of the system or even air trapped if the system was open. Just as on any brake system, air will not eventually circulate through and out; the system is hydraulically closed. If there is air in the system, making the pedal spongy and the braking consequently uncertain, it will stay there until you or someone else bleeds it out.

Because of the additional components on an ABS system, regular brake fluid flushes, at least every other year, are critical to the function of the equipment. Since brake fluid is hygroscopic, it will draw moisture out of the air and get contaminated, even by just sitting with the master cylinder reservoir cap off too long on a humid day. The moisture won't be confined to the master cylinder reservoir but will travel quickly throughout the hydraulic system.

This can have two bad effects, either one potentially disastrous: Just a three percent contamination of brake fluid can lower its boiling temperature down to about three hundred degrees instead of the five to six hundred right out of the can. Those Autobahn brakes can develop a higher temperature than that, particularly on a long, downhill grade. Should the brake fluid boil, it changes from a fixed-volume hydraulic fluid to a variable-volume pneumatic gas. Then the pedal falls to the floor, and the brakes cease their decelerative work. Your customer could develop a sudden interest in finding one of those runaway truck lanes.

The second effect takes longer but could be more insidious still. Rust. The moisture-contaminated brake fluid contains can start the formation of rust anywhere inside the hydraulic circuit. It doesn't have to be in the master cylinder. Just as, if you accidentally put salt in your coffee instead of sugar, you can taste it at the top of the cup even if you don't stir, moisture can travel through the brake fluid – to a distant wheel cylinder, to a pressure reservoir, to an ABS pump. None of this area is a good place for abrasive particles that could lodge in valves or anywhere else, locking components internally. No such rust damage would be inexpensive to find and fix; sometimes it could be dangerous.

Wheelspeed sensors generate signals for the ABS system as well as whatever other traction control systems may be on the vehicle. These are electric induction coils wound around magnets, placed adjacent to toothed gearwheels machined into the hub or axle. As the wheel turns, the sensor reports its speed to the control unit, which then operates the traction controls, as circumstances require.

For each vehicle, there is a specific bleeding procedure. There are more models of Mercedes-Benz on the road than there are pages in this magazine, so we won't try to outline them each, but here's the way most work. First, vacuum the old brake fluid out of the master cylinder, getting as much of the old out as possible. If there is any visible debris or discoloration in the bottom, use some fresh fluid as a flush to stir the stuff off the bottom and get it with your vacuum hose. Then fill the reservoir to the full mark. There is just no point in bleeding the brakes without emptying the master cylinder reservoir first, because all of the brake fluid in the system shares the contamination very quickly; you'd just dilute the new fluid right away.

Rear brakes don't have as much to do with the deceleration of most cars because of the 'weight-shift' as a car slows. On larger vehicles, though, there is often enough weight on the rear that it still has a significant role to play reducing speed. At the same time, of course, ABS and the other traction controls must insure the rear wheels always retain traction.

Often there are tiny bubbles entrained in the new brake fluid just after you pour it in. Let them float to the surface and pop. The last thing you want from your brake flush is the insertion of air into a hydraulic system that didn't have any to begin with.

If your job is just an ordinary brake fluid flush and there is no reason to suppose there's air in the system anywhere, you can go on to bleed the brakes through the calipers. For most models, the sequence is right-rear, left-rear, right-front and left-front, working from farthest away from the master cylinder to closest. However, if you've opened the system anywhere to replace a brake line, caliper or whatever, bleed that circuit first, so no air from it can sneak back into the rest of the system. Then do a complete system flush starting at the right-rear.

For many Mercedes-Benz master cylinders, there is a bleeder on the master itself to allow bleeding it after replacement or repair without risking pumping air through the whole system, perhaps entrapping the air in some particularly recalcitrant backwater of the hydraulics. Many later model cars use a master cylinder with an electric valve that opens or closes to regulate the pressure differential between the separate hydraulic circuits; some have pushrod-position or motion sensors. Be sure to follow the instructions that come with the cylinder to get all the air out of the master cylinder before flushing the rest. Several other components on the more complex brake hydraulic systems also include individual bleeders, used when those components themselves get replaced.

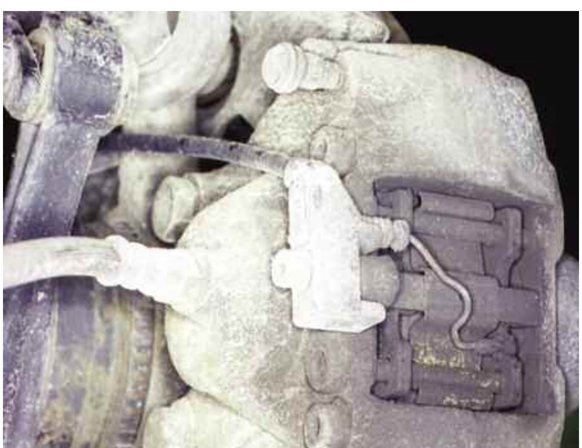
Wheelspeed sensors are electromagnetic generators internally. On most Mercedes-Benz vehicles, the sensors are at each wheel, monitoring the rotation of a toothed wheel on the hub. On some earlier models, however, look for the sensor at the nose of the differential, monitoring the average speed of both rear wheels rather than each of them individually. The sensor works the same way in any case.

Brake Noise

We talked about the runaway truck escape lanes. There is another connection between powerful brakes and trucks: noise. Sometimes under hard braking even the most elegant of cars will produce brake noise that can alarm the driver and passengers. If the noise is a metal-on-metal grinding or clanking, there is a serious problem, but most brake noise is merely a high-frequency resonance between the brake pads and the rotors. For the most part, this is merely an acoustic nuisance and not a matter of brake safety. The car can still be driven; there is no emergency.

That being said, a major reason why brakes make such noises is the use of substandard brake friction materials or failure to replace hardware, such as antirattle springs and pins. The difference in cost between the parts is not worth the difficulties caused by the noise the cheaper parts cause.

A similar story can be told about disks. If you've worked on Mercedes-Benz brakes for some time, you already know disk warping is very rare because the disks and hubs are so robust. Except under unusual conditions or abuse (like constant left-foot braking), the disks last a long time. Rather than machining them or resurfacing them, the carmaker recommends their replacement if the surface of the brake disk has worn beyond normal limits or beyond normal surface conditions.



The rear caliper on this 140 shows the wear sensors on the brake pads. When the pads wear to the point of replacement, the driver should see a caution light informing him or her of it.

Brake Fluid

Everyone knows to change the engine oil with a certain regularity, but the importance of changing the brake fluid is not as widely understood. Brake fluid is, of course, an oil, but a very particular kind of oil. Its most important properties are: It must not cause corrosion in the internal parts of the system, and it must not sustain significant change of hydraulic properties because of heat. The heat of braking a vehicle from a high-cruise speed can be quite high, particularly when descending a long mountain grade.

Brake fluid is hygroscopic. That means it will draw water from any source it can – from the air, from any local water, from your skin. That property of drawing water from things means it will not allow moisture to puddle anywhere in the system: It will draw it into the oil and disperse it throughout the system. Up to a point, this prevents rust.

But there is a fly in the brake fluid's hygroscopic ointment. As the oil draws moisture from anywhere in the hydraulic system and disperses it throughout, that lowers the boiling point of the brake fluid oil.

Brake components require not only precise metallurgy for the casting but precise machining to insure all of the mounting surfaces and hydraulic internals fit the car precisely. Ordinarily it is good practice to replace, say, wheel calipers or disks in axle-pairs to keep the braking performance exactly equal from side to side.

Right out of a new bottle, the boiling point is well over 500 degrees. There is little chance of any braking emergency that will continue long enough over a long enough downhill stretch to raise the brake fluid to that temperature, no matter what. Even under the highest extremes of racing, with the brake disks

It's odd to say it, but true. Antilock brake systems are not there to improve the vehicle's braking but to retain its steering control. There are people, to be sure, who think antilock braking is a kind of magical slowdown system that can stop their car on a dime even if they were driving on glare ice or buttered glass pavement. This is neither the effect nor the design objective.

The purpose of antilock braking, of ABS (*Antiblockiersystem* – anti-wheel-lockup system), is to do everything possible to prevent the tiretread from separating from the pavement beyond the small couple percent at maximum traction demand (whether curving, accelerating or braking). Everything possible, that is, by modulating the hydraulic pressure to the brakes. Later, more complex systems would involve the engine output as well as active application of the brakes under various circumstances to control wheelslip under acceleration, in steep turns and the like. But the ABS we'll focus on here just works the brake system.

glowing bright red under repeated forceful deceleration, the brake fluid itself will hardly come anywhere close to that. The brake pads function as thermal insulators, and the thermal mass of the metal in the steering and rear wheel knuckles as well as in the calipers prevents such a high temperature.

Let some time pass, however, and we have a different story. Regardless of how well the brake fluid is protected from the outside environment by steel and plastic, a certain amount of moisture will creep in. This need not be in the form of beads of moisture condensing on the master cylinder reservoir cap. Individual molecules of water can wind their way up the reservoir cap threads or creep around caliper piston dust boots and seals. You need only an amazingly small amount of seeped and penetrated moisture to poison the batch: When a mere three percent of the brake fluid is absorbed moisture (and an open container could draw that much out of a humid atmosphere in no time), the boiling point of the brake fluid falls to about 300 degrees F.

That seems pretty hot compared to the general atmospheric temperatures in which we drive, but it is much lower than the brake fluid's original 500+ degree boiling point. Now we have a real problem, a serious problem. Maybe a problem that could result in someone's injury or death.

If the brake fluid does boil, that's not just a matter of temperature. When it boils, it changes from liquid to gas. And in a hydraulic system, this is a catastrophic change because a fluid retains a constant high pressure everywhere in the system regardless of temperature because it is incompressible. But when it boils, it's no longer a fluid but a gas. A gas, however, compresses as easily as air.

In a brake hydraulic system, that's bad, very bad. It's as bad as a total loss of hydraulic pressure by a broken line or other complete fluid leak. The brake pedal can fall to the floor under the driver's panicked foot. The usual hydraulic pressure, multiplied by the ratio of master cylinder piston area against the calipers' total, adding the multiplication (about three times) the vacuum brake booster adds to the system, falls to almost nothing. In an ordinary brake system, with undiluted brake fluid, the hydraulic pressure can reach well over a thousand psi. – nearly to Diesel injection pressure levels. In a system with boiling from heat, that pressure can fall to three or four psi. That won't have any useful effect on the brakes; it won't force the shoes against the disks enough to slow the car. When the brake fluid boils, for all practical purposes you have *no* brakes. That's true whatever kind of car you're driving, whether it has ABS or not.

There's no way to prevent this other than flushing the brake fluid at regular intervals, usually every two years. The general principle is to pressurize the system from the master cylinder and bleed the old fluid and any air out from the individual wheel calipers.

But ABS, as well as ASR and several other traction-retention systems complicate this procedure. You can't just pump up the pressure and release the bleeder any more, as though you were working on a car from the 1970's. There are several additional steps and a specific wheel-by-wheel sequence to follow. Do it another way, and you've decided you know more about the system than the engineers who invented it. The best strategy is to follow the procedures set forth by the vehicle manufacturer in Untertuerkheim.

PARTS NEWS

EMISSION COMPONENTS

As more localities make emissions inspections a prerequisite to registering or renewing a car's license, more diagnostic and repair work focuses on emissions-related technologies in the vehicle. Though some inspections are relatively perfunctory, in other places the vehicle must come very close to the emissions standards it met the day it rolled out the factory door. That not only means all the emissions-related systems must be functional, but they must work almost identically to their original condition. OBD II CEL standards for many parameters allow a variation of no more than 50 % from the set values. Let more than one component wander from its original performance by some fraction, and the total can easily be enough to trip the emissions standards.

It is enough of a problem to determine just what is amiss if a vehicle should fail a test, especially factoring in the nagging suspicion there are an irreducible number of false-failures. The last thing you need, if you're doing emissions work (or any other, for that matter), is to complete your testing, settle upon a component and replace it only to still have the same problem. On those memorable occasions when that problem turns out not to have been anything wrong with your diagnosis or work, nothing additional with the car you were working on, but instead a defective replacement part, it's easy to feel a certain irritation at the parts manufacturer.

Vapor Valve

Your chances of feeling that irritation, to say nothing of your chances of wasting all the time it takes to diagnose and repair the car in the first place and then repeat a diagnosis only to find the defective new part – those chances are minimized if you use a part not just similar to but identical with the one that the car had in the first place, the part they used at the factory. It is not merely that short cuts and manufacturing economies could unde the quality of a part.

Canister Valve

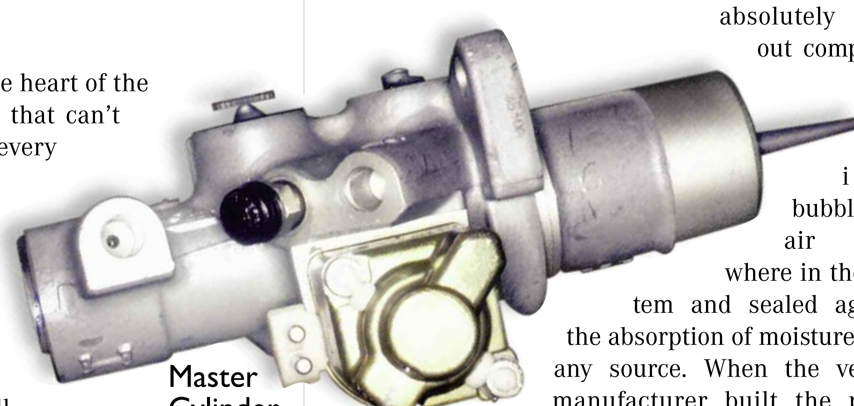
When a part is manufactured by a group of people who not only understand its role in the complete vehicle system, but who invented that complete vehicle system in the first place, who take pride in their invention of a long series of such systems – you can count on that part to work the way you expect. Besides, while carmakers provide complete information about their emissions systems, their diagnosis and repair, they are not inclined to broadcast all the manufacturing technology and testing that went into the design and construction of the components. Somebody else, however skilled, trying to make a copy of the part is guessing and hoping to a large extent.

This is a particular concern when it comes to emissions parts, because there is rarely a way you can tell what the components do by a visual inspection since most emissions components eventually work chemically. Unlike brake disks or connecting rods or steering knuckles, you can't necessarily tell by looking at an EGR valve or a charcoal canister purge valve when it's supposed to do what. You have to work within an understanding of the whole system to diagnose and repair it, and the parts manufacturer requires the same understanding you do to build the part in the first place. Mercedes-Benz consistently builds emissions components to that level of understanding.

Besides their role in keeping the car's exhaust and vapor emissions within the standards set by air quality regulations, emissions components are now so closely integrated with the rest of a vehicle's engine and drivetrain management systems that what some time ago would have been an isolated emissions fault can now have effects on driveability and other vehicle aspects far removed from the tailpipe. Emissions control could even extend to the elimination of blue language on the part of an otherwise disappointed customer.

Dependable Brakes

Brake hydraulics lie at the heart of the deceleration system. A car that can't stop perfectly dependably every time should be parked until a skilled, professional mechanic sets its brake system back to a reliably functional state. Of course, brakes are, with steering, almost the highest liability work you can do. Your partner in that work is the manufacturer of the parts you use. Do you know who that is? Could you find the person responsible for the quality of the part you installed if you had to? Do you know the extent, if any, of the vehicle testing and manufacturing experience they have?



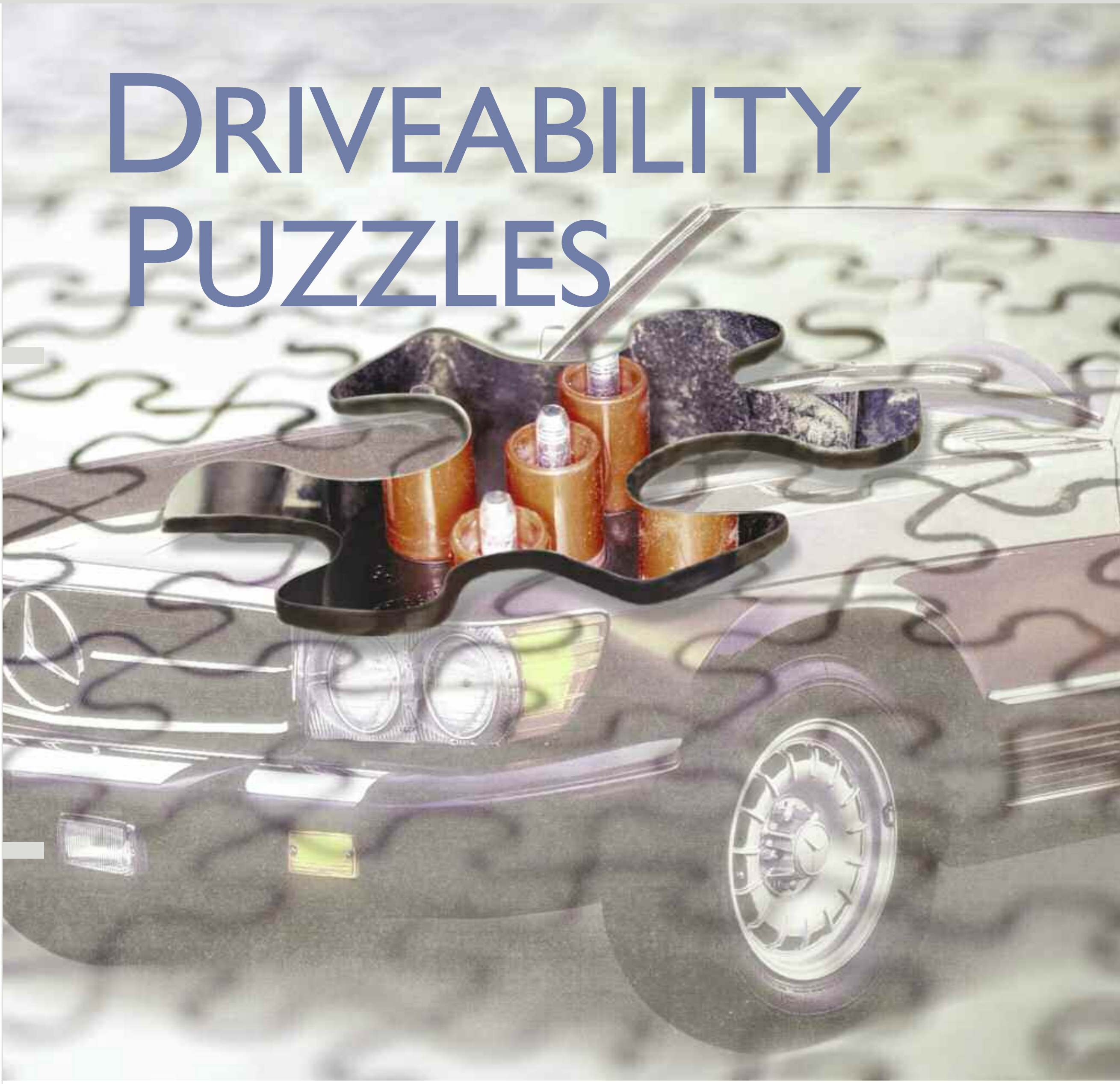
Master Cylinder

When you're working on high-liability systems like braking, there's much to be said for working in partnership with the manufacturer of the vehicle, with a company that's built their products in the same city for over a hundred years. They're not going to disappear; they're not disguised behind a blank white label. Get a master cylinder or a brake caliper from them, and you've tapped into a century of technical research and competence. This depth of resources is just not available anywhere else for any price, never mind at a discount.

Besides the effectiveness and suitability of the part for its hydraulic role, another factor to consider is how easy it is to work with the component. A master cylinder like the one in the photo, for instance, that includes its own dedicated bleeder port can save many hours of brake bleeding, while you try to get the last bubble of air out of the system. In the absence of that bleeder, a master cylinder replacement could be a much more frustrating job, taking longer and with a much greater risk of unsatisfactory results, both for the motorist and for the shop. When you find parts that lend themselves easily to the intended application, you can depend on high levels of mechanical experience on the part of the parts maker. That's experience just like your own and on the same vehicles.

Brake hydraulic components, however competently produced, require extended testing and an accurate, precise assembly procedures. What you have to achieve is a hydraulic system absolutely without compressible bubbles of air anywhere in the system and sealed against the absorption of moisture from any source. When the vehicle manufacturer built the parts, they thought these problems out and arrived at solutions to them, or continued testing until they did. Get the technical information as well and follow the recommendations of the vehicle and component designers and builders. What better partnership can you form with a supplier?

DRIVEABILITY PUZZLES



What an awkward word! But it should be awkward; we use it vaguely to describe a large variety of awkward problems. Generally speaking, anything that goes amiss among the ignition key, the accelerator pedal and the drivewheels is a driveability problem. Well, OK, maybe not a flat tire, but almost anything else. So if there's a vibration when braking or turning, that's not a driveability problem; but if there's one while accelerating or decelerating, it is. If a car doesn't accelerate properly because the parking brake drags, that's not a driveability problem; if it doesn't accelerate properly because the timing chain is off one tooth, it is. All right, I grant you, some we won't know about until we solve them.

We can divide driveability problems between those that set a DTC and those that don't. Of course, even this is at least partly artificial. Given the complexity of a modern engine management system, it is entirely possible that exactly the same driveability problem could set a code in one car and not in the next. What's more, sorting between codes and no-codes doesn't really correspond very closely to the vehicle systems – sometimes a system sets a misleading trouble code as a consequence of the original problem or so many such incidental trouble codes, you know things couldn't be as bad as that, or all the doors and fenders would fall off the car. However, it is a convenient way to divide them up for diagnostic purposes, so we'll follow it here even knowing there are contrary quibbles. This issue, we'll look at some uncoded driveability problems and next time at those with codes.

Why the Codes?

Isn't it handy that automotive engineers designed systems with self-diagnostics? Now, as they say, cars can fix themselves, or at least diagnose themselves. Right. Just as some people believe the computer now can tell you what part to replace, other people think the system was designed to make repair easier. Nope. The OBD II system exists to optimize the vehicle's emissions by making a failure in the emissions systems more evident and then diagnosis and repair of those systems more transparent. If that makes the rest of the car's systems easier to work on, good. But that's not the original purpose of the emissions regulations.

But it is why an emissions system can be good for solving driveability problems: When things go wrong that affect how the car delivers torque to the drivewheels, this usually involves something that has degraded the emissions performance. So we can use that decline in the emissions-control function as a key to solve the other problems, perhaps the one the car's owner actually notices and cares about directly.

This kind of problem is inescapably anecdotal, the stuff of shop 'war stories' – the cars that left everyone pulling his hair for days, the cars that made you realize there was a good side to the landfill business, the cars dragged on a hook or flat-bedded from one unhappy shop to the next until finally they came to you. But they're also the cars that give you the most interesting challenges, the cars that build your reputation as no others can, the cars that owners keep bringing back to you as long as they have the car because you're 'the only one who could fix it.' So it's usually worth the extra time and effort required to unravel that first, nearly impossible problem. Of course, the secret of these 'nearly impossible' problems is usually something you realize afterwards was head-bangingly simple, just not obvious.

Fastidious Failure

The owner of this 126 (engine 117) really liked his car clean and polished. And that's fine. Keeping a car clean and bright keeps the paint clear and prevents rust. While modern paints are much more durable than the stuff used before, a good wax still provides some measure of extra protection for the finish. Regular cleaning removes the residue of road salt and sand that otherwise builds up in all sorts of places under the car, all with bad effects. Besides that, people who keep a car meticulously clean are somewhat more likely to take care to have regular maintenance done properly, as did this car owner.

This car owner took pride in keeping his 126 looking like it just rolled off the PDI line. The paint and chrome were bright; the glass was clear; the leather looked fresh and felt smooth and pliable. He even kept the engine sparkling because he liked the gleam of the shining, powerful motor under the hood. He had gone so far as to wax and polish the top of the air cleaner and a few other visible engine components.

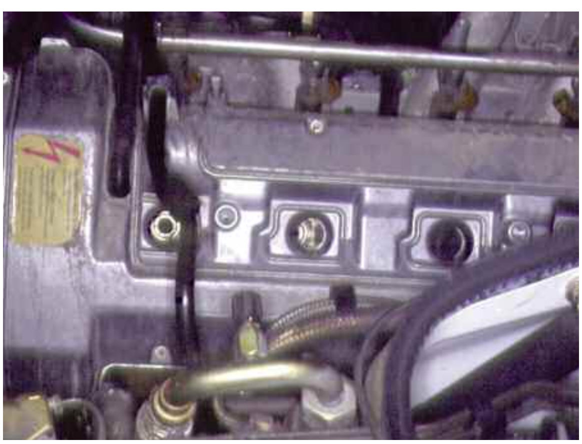
Imagine his irritation and alarm, then, when after one particularly thorough cleaning, the car ran with a shaky engine. He thought, reasonably enough, something had gone damp but would dry out as soon as he drove far enough for the engine to run at normal operating temperature for an hour or so.

Not a bad plan, if it had worked. It didn't, of course, or you wouldn't be reading about it here. The shake continued, and though he sometimes thought it was getting better, after a day or so he had to finally admit to himself that this was just the power of suggestion. So he brought the car to the shop that regularly worked on his Benz.

At the shop, they knew this car owner and the care he took with his car. It also seemed to them likely that water had crept somewhere into a coil secondary boot or cable insulator to short out the spark, though there was always the possibility of some problem in the fuel injection system. But they reasoned further, with a damp secondary circuit, the miss must have continued long enough for a carbon track to grow, and so they concentrated on chasing that.

A power-balance test quickly identified two cylinders, each with a constant miss, the first two on the driver's side, cylinders 5 and 6. But the oscilloscope spark patterns to those cylinders and to all the others looked very close to normal, neither crimped down to low voltage through a dead short nor popped up to coil output max by an open secondary. The shop was not inclined to run a compression test this early in the diagnosis because there seemed such little chance of a sudden, two-cylinder loss of compression just because the owner washed the car. Besides, in the sound of the starter crank, you usually can hear a cylinder-specific compression loss, and everything sounded normal on this one.

But a fuel problem was another story, at least for the cylinders with the leak. The connectors are relatively more exposed to spray and potentially knocked loose by a brush or a blast. But checking the resistance through each of the suspect injectors showed them right on the money, and the harness showed the right pulse for a plausible time when the engine was running. That left a plugup or other mechanical block to the fuel, unlikely on two adjacent cylinders but nowhere else. Monitoring pressure drop from the engine-off residual showed each of them was squirting fuel.



Then came the return to fundamentals, which we all know should have been the first step all along, but all of us forget from time to time, as did the guys in this shop. Driven by the elimination of all the more plausible alternatives, they went back to a compression test, although they just knew the compression was fine. And they were right, the compression was the same as for the other cylinders. But doing the compression test solved the problem. When they pulled the covers and boots off the plugs down in their wells, the cylinder misses were clear: Water had puddled around the spark plugs in cylinders 5 and 6, blown in by the force of the relentless cleaning. When the water got deep enough, the spark chose it as the laziest path to ground, not the path through the ground electrode of the spark plugs. But the resistance of the water was still more than a dead short would have been, so the scope patterns still looked within a normal range.

Several other spark plug wells had water in them, too, but not deep enough to ground out their cables. The engine's ignition shielding could keep water out while driving normally, even during drenching rainstorms, during anything short of submersion of the engine under water. But the over-vigorous engine spray cleaning blew water in unanticipated directions, around the ignition shields, under the plastic and into the plug wells. Some wells should have water in them, but not these! Continued long enough, the water and the consequent secondary partial short could have caused dilution of the crankcase oil with the fuel passing the rings, accelerated wear of the engine from the thinned lubricant, a considerable increase in fuel consumption and a large variety of other maladies. Fortunately, the shop had the foresight to blow the water out with compressed air before pulling the plugs (a good shop policy when removing plugs under any circumstances), and the fastidious car owner let prudence subdue his enthusiasm for tidiness around electrical components thereafter.

Enough's Enough

Well, this was really annoying. The customer drove in with a fuel line leak. The shop fixed that with no particular problem... er, except that then the car wouldn't start. Arguably, this is better than the risk of a pump-fed car fire, but the shop already knew the customer would have reservations about that improvement. Spark was sharp and bright, fuel pressure was not only good, but almost 1.0 bar high, over what the specs called for. The battery was several years old, but the tests showed it putting out all the amps you'd want while keeping the voltage over 10 volts. Nonetheless, it was a battery brand the shop had bad experiences with, so they tried replacing it with another from inventory, all (how'd you guess?) to no avail.

They pulled the plugs, which were not the brand specified. So they replaced the errant plugs with new ones from the proper source. But the car was unconvinced and still didn't start. They threaded in another fuel filter and installed another distributor rotor, although there was no particular reason to suspect the problem lay there.

If you guess at an answer and bolt in parts to suit, your odds of fixing the car are just about zilch. And that's what the shop found. Their new rotor and filter appeared to work fine, yet the engine appeared to fail to start every time. Finally, in desperation, they searched around their parts inventory for things to dump on the car in hopes one of them would work.

A spanking new neutral/safety switch made a dashing fashion statement on the underside of the car. But the engine remained quietly nonfunctional. A second new set of spark plugs effectively emptied the boxes of plugs, but left the engine still, after a moment's deceptive startup attempt. The only component left was a fuel pressure regulator, bolted on without enthusiasm, only because it was the only thing left on the shelf that fit this car.

The engine started up and ran perfectly normally. Evidently the high pressure was enough to flood the plugs every time. It's natural to assume the specifications allow a certain amount of tolerance on either side of the spec. But it's mistaken to suppose this is unknown to the folks back at the factory. When they list a fuel pressure specification or some other vehicle running specification, they have the means to check and determine what the limits of the tolerance are. If there's a range of fuel pressures the system can work with, they had the best chance of anyone to test and determine this. They have no motivation to fib about it, so you can take their numbers seriously. If they say the fuel pressure at crank should be between 84 and 102 psi., it's most likely the car won't start or run below 83 or above 103. They had every reason and every opportunity to find out the real numbers and report them accurately; they had no reason to fake the results.

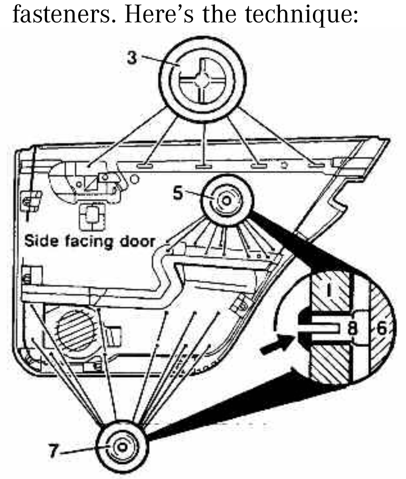
Factory specs are not guesses or wishes. They really are serious about running the tests and making the measurements. If something falls outside those specifications, that something is amiss; it requires testing and correction on your part. Do not be misled by assumptions that the factory fluffed the numbers for one reason or another. At least with these cars, they didn't.

FACTORY SERVICE BULLETINS

These suggestions and solutions for technical problems come from service bulletins published by Mercedes-Benz, selected and rewritten for independent repair shops. Your Mercedes-Benz parts source can obtain any designated by parts number.

Rear Interior Door Panel Disassembly Model 202

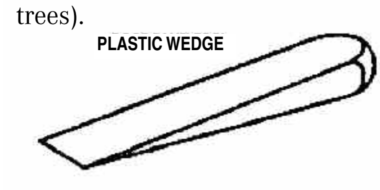
If you have to open up these rear doors for testing or repair, you probably would like to buy a minimum number of replacement parts, preferably only inexpensive fasteners. Here's the technique:



3 Wood trim lock
5 White plastic mounting studs for armrest
7 Black plastic mounting studs for door pocket
1 Rear interior door panel
8 White/black plastic mounting stud Armrest/door pocket

Remove the panel using a plastic wedge and unscrewing the Philips screws in the locations shown in the line drawings. There are several door interiors, but the attachments are similar. Place the panel you removed on a clean surface to avoid getting anything on the side that shows. The inside of the panel should be upward, the visible face downward.

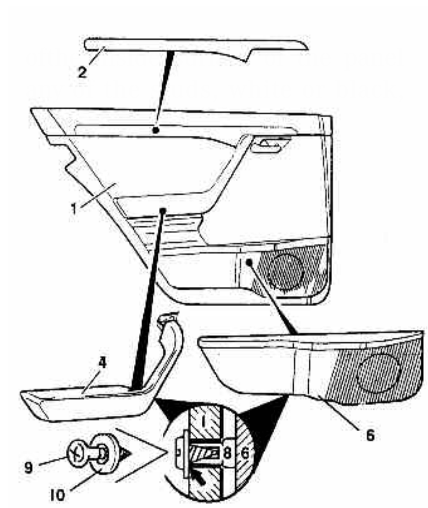
Remove the wood trim locks (3) from the door panel back and carefully remove the wood trim from the panel. Be careful with the wooden parts because the color is hard to match, particularly after a few years (they were different trees).



Use side snips or a 5/8-inch chisel and small hammer to remove the rounded portion (arrow) of the *white* plastic mounting studs (5) for the armrest. Gently and carefully, remove the armrest from the door panel. Since the white plastic studs are soft, don't use a drill to remove the rounded tips because the bit will penetrate the plastic too deeply, and you may not be able to re-use the armrest.

Use a slow turning 10-mm drill bit to remove the corresponding rounded tips of the *black* plastic studs for the door pocket. Gently and carefully, pull the door pocket away from the interior door panel.

Putting things back together, insert the armrest and door pocket into the panel. Cut off the ends



2 Wood trim
1 Rear interior door panel
8 White/black plastic mounting stud
4 Armrest
6 Door pocket
9 Screw
10 Washer

of the studs flush with the surface. The ends of each of the black and white studs should be exactly flush with the door panel surface when properly installed.

Put a washer [p/n N 000125 005312 (210)] over each of the white/black plastic mounting studs. Thread in and tighten a screw [p/n N 914138 004000 (21)] into the existing bore of the studs. Reposition the wood trim into the panel and secure with the wood trim locks you removed originally. If any wood trim locks were damaged in disassembly, replace them or the wood trim may be loose.

MBNA 72/13

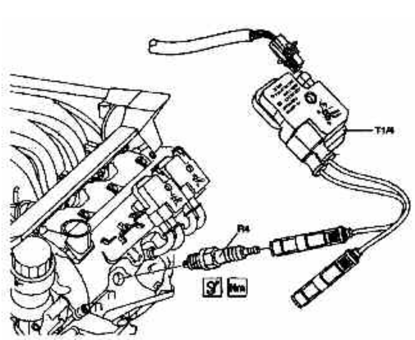
Soggy Rug, Sooty Exhaust? Model 163 and Others

Model 163 is somewhat more likely than other Mercedes-Benz vehicles to end up with a wet carpet under the front seats from melting snow, water and the like because it is somewhat more likely to be used off-road. But the problem can affect any vehicle whose oxygen sensor harness routes through the compartment in that area. That moisture can start corrosion in the connectors for either oxygen sensor if it remains for any length of time.

If there is excessive corrosion on the terminals, replace them and cover the connectors with a watertight sealant. If you can clean the terminals for a good connection (and remember, an oxygen sensor does not have a very high voltage or current, so any resistance will affect the signal), just use the sealant, dry out the carpet and inform the car owner of the importance of keeping this area relatively dry.

10M/99-2

Coil Corrosion All Models with Gasoline Engines



If your diagnosis of an ignition problem leads you to the ignition coil, be sure to check all the connections, primary and secondary, to that coil. A high resistance connection, or even a connector that is not fully seated in the housing, can produce exactly the same symptoms as a defective coil. Worse still, when you replace a good coil with such a bad connection, you will probably connect the unnecessary new coil properly, making you think the coil really was needed. This test consists of a careful visual inspection of the coil and its connectors before you discard it.

04/98-4

False Failures All models with LH-SFI or HFM-SFI, 1993-1996

Mercedes-Benz vehicles with the systems and from model years identified may fail OBD tests in some states that established their test procedures without knowing how these Mercedes-Benz systems operate. Certain localities automatically fail any vehicle if the MIL lamp is on with the vehicle in any key-on/engine-running condition or if the MIL comes on after the vehicle is started, even with no fault codes present (on the theory this represents a serial data link failure).

But certain Mercedes-Benz vehicles turn the MIL on during DTC readout and/or while the tool is connected, regardless of whether there are faults present in the OBD system or not. This feature was designed into the control modules for early OBD systems so a technician could tell when a tool properly communicated with the control module. In this case, the MIL is only illuminated as a test; it is not 'commanded on' as in any case when an emissions-related fault has been recorded. A list of affected vehicles is in the service bulletin listed here.

P-SI-14.00/14

Blown Fuse Model 140

If you're doing any kind of work that involves removal of the center console wood trim, you'll remove the ashtray cover first. Most likely, you'll turn the ignition key on and push the brake pedal so you can move the shift lever out of Park and have enough room to get in with an offset screwdriver. But if before you start to work, you take the precaution to then turn the ignition off with the shift lever still out of Park, you shut off the current to the cigarette lighter. Touching the terminals with the screwdriver could pop the fuse, of course, but you might not notice the bad circuit until the motorist brought the car back with that complaint.

MBNA 68/3

ABS and Cruise Control Diagnosis Models 124, 129 and 140

If you're diagnosing one of these models with ABS or cruise control, check to see whether it includes ASR (Acceleration Slip Regulation) before you get far into the job. Diagnostic testing of ABS on cars with that system is covered in the ASR section of the Diagnostic Manual, available from Mercedes-Benz Technical Information. Section 6 of the manual applies *only to vehicles without ASR.*

Similarly, the same models cover diagnostic information on the cruise control system within the ASR diagnostics, not separately. You'll find it covered under the Electronic Accelerator test.

MBNA 30/5, 42/9


Star Quality
Mercedes-Benz Wheel Care
Safely and effectively cleans all wheels.
Quick Wipe
Safely removes contaminants between washings; enhances gloss.
Car Shampoo
Safely cleans exterior surfaces without stripping wax.
Paint Care
Cleans, polishes and protects in one easy step.
The only way to pamper your Mercedes-Benz is with our exclusive line of car care products, specifically formulated for your automobile and available only at your Dealer.
Meguiar's since 1901
meguiars.com
carcrazycentral.com
Customer Help Center 800-347-5700

STARTUNED

MERCEDES-BENZ PARTS... NEARBY

Alabama

Dothan
Rahal-Schmitz
334-794-6716

Hoover
Crown Automobile Company, Inc.
205-985-4200

Huntsville
Regal Auto Plaza
256-837-5752

Mobile
McConnell Automotive Corporation
334-476-4141

Montgomery
Jack Ingram Motors, Inc.
334-277-5700

Tuscaloosa
Leigh Automotive
205-556-1111

Alaska

Anchorage
Mercedes-Benz of Anchorage
907-277-3383

Fairbanks
A & B Auto, Inc.
907-456-6161

Arizona

Chandler
Mercedes-Benz of Chandler
480-893-0639

Phoenix
Phoenix Motor Company
602-264-4791

Scottsdale
Schumacher European
480-991-1155

Tucson
Mercedes-Benz of Tucson
520-886-1311

Arkansas

Fayetteville
Jones Motorcars, Inc.
501-521-7281

Little Rock
Riverside Motors, Inc.
501-666-9457

California

Anaheim
Caliber Motors, Inc.
714-777-1900

Bakersfield
Mercedes-Benz of Bakersfield
661-836-3737

Belmont
Autobahn Motors
650-637-2333

Beverly Hills
Beverly Hills, Ltd.
310-659-2980

Buena Park
House of Imports
714-562-1100

Calabasas
Calabasas Motorcars, Inc.
818-591-2377

Carlsbad
Hoehn Motors, Inc.
760-438-4454

Chico
Courtesy Motors Auto Center, Inc.
530-893-1300

Encino
Auto Stiegler, Inc.
818-788-0234

Escondido
Mercedes-Benz of Escondido
760-745-5000

Fremont
Claridge's Ltd.
510-623-1111

Fresno
Herwaldt Motors
559-438-0300

Glendale
Calstar Motors, Inc.
818-246-1800

Laguna Niguel
Mercedes-Benz of Laguna Niguel
949-347-3700

La Jolla
Heinz Gietz Autohaus, Inc.
858-454-7137

Long Beach
Mercedes-Benz of Long Beach
562-426-7301

Los Angeles
Downtown L.A. Motors
213-748-8951

Modesto
Modesto European
209-522-8100

Monterey
Stahl Motor Company, Inc.
831-375-2456

Newport Beach
Fletcher Jones Motor Cars, Inc.
949-718-3000

Oakland
Mercedes-Benz of Oakland
510-832-6030

Palm Springs
Mercedes-Benz of Palm Springs
760-328-6525

Palo Alto
Park Avenue Motors
650-494-0311

Pasadena
Rusnak Pasadena
626-795-8004

Pleasanton
Mercedes-Benz of Pleasanton
925-463-2525

Riverside
Walter's Auto Sales & Service, Inc.
909-688-3332

Rocklin
Von Housen Motors
916-924-7278

Sacramento
Mercedes-Benz of Sacramento
916-924-8000

San Diego
Mercedes-Benz of San Diego
858-279-7202

San Francisco
Mercedes-Benz of San Francisco
415-673-2000

San Jose
Smythe European, Inc.
408-983-5200

San Luis Obispo
Kimball Motor Company
805-543-5752

San Rafael
R.A.B. Motors, Inc.
415-454-0582

Santa Barbara
Cutter Motors
805-682-2000

Santa Monica
W.I. Simonson, Inc.
310-829-4511

Santa Rosa
Smothers European
707-542-4810

Stockton
Berberian European Motors
209-944-5511

Thousand Oaks
Silver Star A.G. Ltd.
805-371-5400

Torrance
Mercedes-Benz of South Bay
310-534-3333

Van Nuys
Keyes European
818-997-8700

Walnut Creek
Stead Motors of Walnut Creek
925-937-1655

West Covina
Penske Motorcars
626-859-1200

Colorado

Colorado Springs
Phil Long European Imports L.L.C.
719-575-7950

Denver
Murray Motor Imports Company
303-759-3400

Littleton
Mercedes-Benz of Littleton
303-738-7700

Connecticut

Fairfield
Mercedes-Benz of Fairfield
203-368-6725

Greenwich
Mercedes-Benz of Greenwich
203-869-2850

Hartford
New Country Motor Cars, Inc.
860-522-6134

New London
Carriage House of New London, Inc.
860-447-3361

North Haven
Mercedes-Benz of North Haven
203-239-1313

Delaware

Milford
I.G. Burton and Company, Inc.
302-424-3042

Wilmington
Pennmark Auto Group II, Inc.
800-800-1949

Florida

Clearwater
Lokey Motor Company
727-530-1661

Coral Gables
Bill Ussery Motors, Inc.
305-445-8593

Daytona Beach
Mercedes-Benz of Daytona Beach
386-274-4775

Ft. Lauderdale
Mercedes-Benz of Fort Lauderdale
954-462-4381

Ft. Myers
Mercedes-Benz of Fort Meyers
941-433-8300

Ft. Pierce
Coggin Motor Mall
561-466-7000

Ft. Walton Beach
Quality Imports, Inc.
850-863-2161

Gainesville
Kraft Motorcar Co., Inc.
352-332-7571

Jacksonville
Brumos Motor Cars, Inc.
904-724-1080

Lakeland
Robert G. Waters, Inc.
863-688-8111

Maitland
Mercedes-Benz of Orlando
407-645-4222

Melbourne
Continental Motorcars, Inc.
321-956-0600

Miami
Mercedes-Benz of Miami
305-919-8000

Naples
Regency Autohaus, Inc.
941-643-5006

Pensacola
Centennial Imports, Inc.
850-432-9903

Pompano Beach
Autohaus Pompano
954-943-5000

Sarasota
Glauser, Inc.
941-923-3441

St. Petersburg
Crown Eurocars, Inc.
727-526-3738

Tallahassee
Capital Eurocars, Inc.
850-574-3777

Tampa
Mercedes-Benz of Tampa
813-870-0010

West Palm Beach
Mercedes-Benz of Palm Beach
561-689-6363

Guam

Tamuning
Atkins, Kroll, Inc.
671-646-2360

Georgia

Albany
Hentschel Motorcars, Inc.
912-883-2040

Athens
Mercedes-Benz of Athens
706-549-6600

Atlanta
Carriage House Imports, Inc.
770-964-1600

Atlanta
RBM of Atlanta, Inc.
770-390-0700

Augusta
Rader, Inc.
706-860-1111

Columbus
Columbus Motor Company
706-327-3636

Decatur
Atlanta Classic Cars, Inc.
404-296-1313

Macon
Jackson Automotive Group, Inc.
478-477-4858

Savannah
Critz, Inc.
912-354-7000

Hawaii

Honolulu
Theo Davies Euromotors, Ltd.
808-592-5600

Idaho

Boise
Lyle Pearson Company, Inc.
208-377-3900

Pocatello
Park Price Motor Company
208-232-1062

Illinois

Arlington Heights
Mark Motors, Inc.
847-259-4455

Barrington
Motor Werks of Barrington
847-381-8900

Bourbonnais
Napleton's Autowerks
815-933-8221

Champaign
Sullivan-Parkhill Imports, Inc.
217-352-4161

Chicago
Loeber Motors, Inc.
312-944-0500

DeKalb
Sawyer Auto Imports, Inc.
815-758-5451

Lake Bluff
Knauz Continental Autos, Inc.
847-234-1700

Lincolnwood
Loeber Motors, Inc.
847-675-1000

Loves Park
Napleton's Autowerks, Inc.
815- 636-6600

Marion
Foley-Sweitzer Motor Sales, Inc.
618-997-1313

Naperville
Mercedes-Benz of Naperville
630-305-4560

Normal
Sud's Motor Car Company, Inc.
309-454-1101

Northbrook
Autohaus on Edens, Inc.
847-272-7900

Orland Park
Mercedes-Benz of Orland Park
708-460-0400

Pekin
Mid/Town Imports Incorporated
309-347-3191

Peru
J.P. Chevrolet GEO Nissan Company
815-223-7000

Springfield
Isringhausen Imports, Inc.
217-528-2277

Westmont
Laurel Motors, Inc.
630-654-8100

Indiana

Evansville
D-Patrick, Inc.
812-473-6500

Fort Wayne
Shaver Imports
219-432-7200

Highland
Terry Shaver Imports, Inc.
260-432-7200

Indianapolis
World Wide Motors, Inc.
317-580-6810

Lafayette
Mike Raisor Imports
765-448-4582

Mishawaka
Gurley Leep Motorwerks, Inc.
574-254-7130

Iowa

Davenport
Lujack's Northpark Auto Plaza
563-388-8610

Des Moines
Mercedes-Benz of Des Moines
515-334-8339

Iowa City
Chezik-Sayer Imports
319-337-6100

Kansas

Shawnee Mission
Aristocrat Motors
913-677-3300

Topeka
Sunflower Motors, Inc.
785-266-8480

Wichita
Scholfield Auto Plaza, L.L.C.
316-688-5000

Kentucky

Ashland
Sim Fryson Motor Co., Inc.
606-329-2288

Bowling Green
Bowling Green Imports
270-745-0001

Lexington
James Motor Company
606-268-1150

Louisville
Tafel Motors, Inc.
502-896-4411

Louisiana

Alexandria
Walker Automotive
318-445-6421

Baton Rouge
Audubon Imports
225-296-7290

Lafayette
Moss Motors
337-235-9086

Metairie
Benson Motor Company
504-456-3727

Shreveport
Holmes European Motors, Inc.
318-212-1212

Maine

Bangor
Quirk Auto Park of Bangor
207-941-1017

Falmouth
Performance Motors
207-781-3207

Maryland

Annapolis
Mercedes-Benz of Annapolis
410-268-2222

Bethesda
Euro Motorcars, Inc.
301-986-8800

Cockeysville
Valley Motors, Inc.
410-666-7777

Hagerstown
Mercedes-Benz of Hagerstown
301-733-2301

Owings Mills
R & H Motor Cars, Ltd.
410-363-3900

Salisbury
Pohanka TM, Inc.
410-543-3411

Silver Spring
Herb Gordon Auto Group, Inc.
301-890-3030

Massachusetts

Boston
Clair International, Inc.
617-469-1000

Boylston
Wagner Motor Sales
508-869-6766

Haverhill
Smith Motor Sales of Haverhill, Inc.
978-372-2552

Hyannis
Trans-Atlantic Motors, Inc.
508-775-4526

Lynnfield
Flagship Motorcars
781-596-9700

Natick.
Foreign Motors West, Inc.
508-655-5350

Somerville
Chambers Motorcars of Boston
617-666-4100

West Springfield
Lewbar Imports, Inc.
413-733-5102

Michigan

Acme
Black Forest Motors
231-938-2840

Ann Arbor
Auto-Strasse, Ltd.
734-663-3300

Bloomfield Hills
Mercedes-Benz of Bloomfield Hills
248-644-8400

Grand Blanc
Grand Blanc Motorcars, Ltd.
810-695-4400

Grand Rapids
Betten Imports, Inc.
616-241-2671

Kalamazoo
Orrin B. Hayes, Inc.
616-345-0167

Novi
Mercedes-Benz of Novi
248-426-9600

Okemos
Williams Auto World
517-484-1341

Rochester
Mercedes-Benz of Rochester
248-652-3800

Minnesota

Bloomington
Terry Feldmann's Imports, Inc.
612-837-6300

Maplewood
Maplewood Imports
651-483-2681

Minnetonka
Sears Imported Autos, Inc.
952-546-5301

Mississippi

Gulfport
Bert Allen Imports
228-864-6622

Jackson
Higginbotham Automobiles, L.L.C.
601-956-4211

Missouri

Columbia
Legend Automotive Group, Inc.
573-875-5000

Creve Coeur
Plaza Motor Company
314-301-1715

Ellisville
Tri-Star Imports, Inc.
636-458-5222

Joplin
Tri-State Import Cars, Inc.
417-781-1177

Springfield
Elite Automotive Group
417-889-5750

Montana

Missoula
DeMarois Olds-GMC Company
406-721-4000

Nebraska

Lincoln
Husker Auto Group. Inc.
402-434-5100

Omaha
Mercedes-Benz of Omaha
402-384-9999

Nevada

Las Vegas
Fletcher Jones Imports
702-364-2758

New Hampshire

Greenland
Dreher-Holloway, Inc.
603-431-8585

Manchester
Holloway Motor Cars
of Manchester, LLC
603-669-6788

New Jersey

Bridgewater
Millennium Automotive Group
908-685-0800

Cherry Hill
Mercedes-Benz of Cherry Hill
856-663-0984

Edison
Ray Catena Motor Car Corp.
732-549-6600

Englewood
Benzel-Busch Motor Car Corp.
201-567-1400

Fairfield
Globe Motor Car Company
973-227-3600

Freehold
David Michael Motor Car Corp.
732-462-5300

Lawrenceville
Mercedes-Benz of Princeton
609-771-8040

Little Silver
Contemporary Motor Cars, Inc.
732-842-5353

Millville
Joseph Pontiac-GMC-Buick
856-293-0003

Morristown
Mercedes-Benz of Morristown
973-267-9200

Newton
Intercar, Inc.
973-383-8300

Paramus
Prestige Motors, Inc.
201-265-7800

Union
Ray Catena Motor Car Corp.
908-964-4000

West Atlantic City
Precision Cars of Atlantic City Corp.
877-5MB-PARTS

New Mexico

Albuquerque
Premier Motorcars, L.P.
505-821-4000

New York

Bayside
Helms Brothers, Inc.
718-631-8181

Binghamton
Feduke Motors, Inc.
607-772-0700

Brooklyn
Sovereign Motor Cars, Ltd.
718-258-5100

Fayetteville
Romano Motors, Ltd.
315-637-4500

Goldens Bridge
Estate Motors, Inc.
914-232-8122

Huntington
Mercedes-Benz of Huntington
631-549-2369

Latham
Keeler Motor Car Company
518-785-4197

Long Island City
Silver Star Motors, Inc.
718-361-2332

Massapequa
Sunrise Motors, LLC
631-789-1600

Nanuet
Mercedes-Benz of Nanuet
845-623-1500

New York
Mercedes-Benz Manhattan, Inc.
212-629-1600

Rochester
Holtz House of Vehicles, Inc.
716-424-4740

Rockville Centre
Lakeview Auto Sales & Service
516-766-6900

Roslyn
Rallye Motors, L.L.C.
516-625-1600

Smithtown
Competition Imports, Inc.
631-265-2204

Southampton
Mercedes-Benz of Southampton
631-283-0888

Wappingers Falls
Friendly Motorcars
845-298-0600

White Plains
Mercedes-Benz of White Plains
914-949-4000

Williamsville
Mercedes-Benz of Buffalo
716-633-0088

North Carolina

Ashevillle
Skyland Automotive, Inc.
828-667-5213

Charlotte
Beck Imports of the Carolinas
704-535-6400

Fayetteville
Valley Motors, Inc.
910-487-0000

Greensboro
Mercedes-Benz of Greensboro
336-856-1552

Hickory
Hendrick Motors
828-322-5640

Raleigh
Leith, Inc.
919-876-5432

Wilmington
Bob King Autohaus
910-799-3520

Winston-Salem
Mercedes-Benz of Winston-Salem
336-760-4580

North Dakota

Fargo
Valley Imports, Inc.
701-277-1777

Ohio

Akron
Ganley Akron, Inc.
330-733-7511

Bedford
Motorcars East
440-439-0100

Canton
Kempthorn Motors
330-452-6511

Centerville
Ross Motor Cars
937-433-0990

Cincinnati
Mercedes-Benz of Cincinnati
610-984-9080

Columbus
Ed Potter, Inc.
614-299-2144

Dublin
Crown Eurocars
614-799-4666

Mansfield
Weidner Motors
419-529-7800

North Olmsted
Motorcars West
440-716-2700

Sylvania
Vin Devers, Inc.
419-885-5111

Tiffin
Coppus Motors, Inc.
419-447-8131

Willoughby
Leikin Motor Companies
440-946-6900

Youngstown
Fred Martin Ford, Inc.
330-793-2444

Oklahoma

Oklahoma City
Mercedes-Benz of Oklahoma City
405-236-1224

Tulsa
Jackie Cooper Imports
918-249-9393

Oregon

Bend
Dave Holt, Inc.
541-382-4040

Eugene
Mercedes-Benz of Eugene
541-687-8888

Medford
Crater Lake Motors, Inc.
541-773-3673

Portland
Mercedes-Benz of Portland
503-228-8351

Salem
Valley Motor Company
503-585-1231

Wilsonville
Mercedes-Benz of Wilsonville
503-454-5000

Pennsylvania

Allentown
Knopf Automotive
610-439-1555

Camp Hill
Sun Motor Cars, Inc.
717-737-3030

Devon
Mercedes-Benz of Devon
610-688-7905

Doylestown
Keenan Motors
215-348-0800

Erie
Contemporary Motorcar Ltd.
814-868-8622

Ft. Washington
R&S Imports
215-646-6045

Greensburg
Bud Smail Motorcars, Ltd.
724-838-1200

Lancaster
Mercedes-Benz of Lancaster
717-569-2100

Reading
Tom Masano, Inc.
610-777-6587

State College
Leitzinger Imports, Inc.
814-238-2447

Washington
John Sisson Motors, Inc.
724-206-6000

West Chester
Brandywine Motor Cars
800-220-7278

Wexford
Bobby Rahal Motorcar Company
724-935-9300

Wilkes-Barre
Motorworld Auto Group, Inc.
570-829-3500

Puerto Rico

Carolina
Garage Isla Verde, Inc.
787-620-1313

Rhode Island

Tiverton
Viti, Inc.
401-624-6181

Warwick
Inskip Autocenter
401-821-1515

South Carolina

Charleston
Baker Motor Co. of Charleston, Inc.
843-852-4000

Columbia
Dick Dyer and Associates, Inc.
803-786-8888

Conway
Fowler Motors, Inc.
843-347-4271

Florence
Newsome Automotive
843-662-8711

Greenville
Carlton Motorcars, Inc.
864-213-8000

Hilton Head Island
Modern Classic Motors, Inc.
843-681-8500

South Dakota

Sioux Falls
Vern Eide Motorcars, Inc.
605-362-9500

Tennessee

Chattanooga
Long of Chattanooga
423-855-3726

Kingsport
Rick Hill Imports, Inc.
423-224-2117

Knoxville
Mercedes-Benz of Knoxville
865-777-2222

Memphis
Mercedes-Benz of Memphis
901-345-6211

Nashville
Mercedes-Benz of Nashville
615-742-8000

Texas

Austin
Mercedes-Benz of Austin
512-454-6821

Beaumont
Mike Smith Autoplex
German Imports, Inc.
409-840-2000

Bedford
Park Place Motorcars
214-443-8290

Corpus Christi
Ed Hicks Imports
361-854-1955

Dallas
Park Place Motorcars
214-526-8701

El Paso
Mercedes-Benz of El Paso
915-778-5341

Harlingen
Cardenas Autoplex, Inc.
956-425-6000

Houston
Mercedes-Benz of Houston Greenway
713-986-6705

Houston
Mercedes-Benz of Houston North
713-986-6250

Houston
Star Motor Cars
713-868-6800

Laredo
Powell Watson Motors, Inc.
956-722-5182

Midland
Britt Imports, Inc.
915-699-7993

Plano
Ewing Autohaus
972-599-0909

San Antonio
Mercedes-Benz of San Antonio
210-366-9600

Temple
Garlyn Shelton Imports
254-771-0128

Texarkana
Pete Mankins Pontiac-Cadillac, Inc.
254-793-5661

Tyler
Classic-Tyler Motors, Inc.
903-581-0600

Waco
Allen Samuels Chevrolet-GEO
254-772-8850

Wichita Falls
Patterson Auto Center
940-766-0293

Utah

Salt Lake City
Ken Garff Imports
801-521-6111

Vermont

Shelburne
The Automaster
802-985-8482

Virginia

Arlington
American Service Center Associates
703-525-2100

Charlottesville
Brown European Imports
804-817-3380

Fredericksburg
Noble Cars, Inc.
540-373-5200

Hampton
Tysinger Motor Company, Inc.
757-865-8000

Lynchburg
Kenneth Hammersley Motors, Inc.
804-385-6226

Richmond
David R. McGeorge Car Co., Inc.
804-755-9300

Roanoke
West Motor Sales
540-344-6284

Vienna
H.B.L., Inc.
703-442-8200

Virginia Beach
Phillips Automotive, Inc.
757-499-3771

Washington

Bellevue
Mercedes-Benz of Bellevue
425-455-8535

Bellingham
Wilson Toyota
360-676-0600

Fife
Mercedes-Benz of Tacoma
253-922-6820

Pasco
McCurley Imports
509-547-5555

Seattle
Phil Smart, Inc.
206-324-5959

Spokane
Sutherland Motors, Ltd.
509-455-9100

Yakima
Hahn Motor Company
509-453-9171

West Virginia

Charleston
Smith Company Motor Cars
304-746-0600

Morgantown
University Motors, Ltd.
304-296-4401

Parkersburg
Astorg Motor Company
304-422-6403

Wisconsin

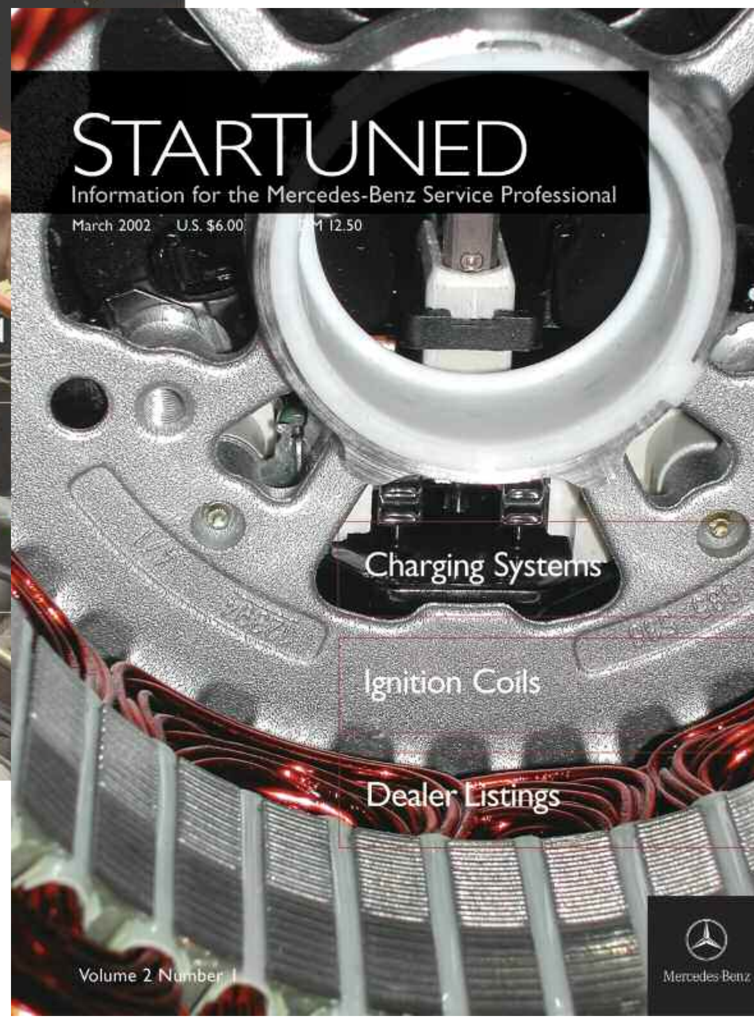
Appleton
Enterprise Motorcars, Inc.
920-749-2020

Glendale
Concours Motors, Inc.
414-290-1400

Madison
Z European
608-258-4000

Wausau
Rosemurgy International
Auto Mall, Inc.
715-675-7775

West Allis
International Autos, Inc.
414-543-3000



DON'T MISS OUT!

Mercedes-Benz is committed to building lasting relationships with our customers. One more way we are doing this is with *StarTuned* magazine, available through your authorized Mercedes-Benz dealer. Don't miss out on future issues.

Contact your local Mercedes-Benz dealer's parts department now.

Mercedes-Benz

THERE'S NO BETTER PROTECTION FOR YOUR REPUTATION.

There's nothing like trust to keep your customers coming back. Which is why Mercedes-Benz and AMG rely on Mobil 1. Now Mobil 1 features the new SuperSyn anti-wear system. This patented technology represents the most advanced Mobil 1 engine protection ever. The more heat and friction threaten an engine, the more you can trust Mobil 1. So why give your customers anything less than Mobil 1? There's no better way to take care of a Mercedes-Benz. Or business. For more information, call 1-800-ASK-MOBIL or log on to www.mobil1.com. Nothing outperforms new Mobil 1.

THE MORE YOU KNOW ABOUT NEW MOBIL 1, THE BETTER IT IS FOR YOU, AND YOUR CUSTOMER.

Mobil® Command Performance